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CONVOY ACTIVE SAFETY TECHNOLOGY

ENVIRONMENTAL UNDERSTANDING AND NAVIGATION WITH USE OF LOW COST SENSORS

9 August 2012

GVSETS

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Introduction

- CAST Background
- System Description
- Low Cost Sensor Fusion
- Vehicle Detection
- Vehicle Tracking
- Trajectory Generation
- PVF General Results
- Conclusion

CAST Background

ROBOTIC SYSTEMS

Capabilities

- Improved Operator Safety and Security:
  - Eliminates Rear-End Collisions
  - Reduces Fatigue & Eliminates Road Departures
  - Enables Hands-Free Response to Attack
  - Reduces Collateral Damage to Civilian Population
- Improved Operator Situational Awareness:
  - Increased IED Detection Rate
  - Ability to Detect Threats at Greater Distance
- Automated Obstacle Detection and Avoidance
- Fully Operational Across Typical Mission Needs at speeds consistent with human operators
- Autonomous multi-vehicle convoys for March Units up to 25 vehicles
  - AutoMateTM kit still allows for manual operation of any tactical wheeled vehicle
  - Ability to maintain convoy speeds consistent with human operators

Flexibility to Commander in field

- Fast, <10 sec, convoy configuration Ability to change parameters on the fly

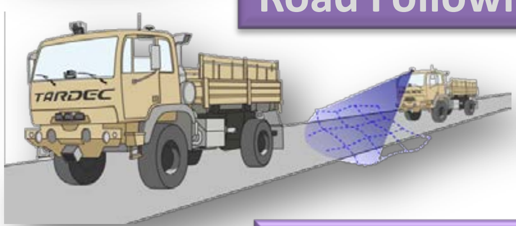
History & Status

- Initiated by TARDEC (2005) on Very Limited Budget
- Conducted Initial Feasibility Demonstrations:
  - Fort Carson (February 2006)
  - Fort Gordon (November 2006)
- Conducted Extensive Warfighter Experiments:
  - Fort A.P. Hill (November 2007)
  - Nevada Automotive Test Center (November 2008)
  - Fort Hood (Robotics Rodeo) (September 2009)
  - Fort Benning (September 2010)
- Specified in Operational Needs Statement:
  - Validated & Signed by Dep Chief of Staff (Nov 2009)
- CAST forms basis of AMAS JCTD

CAST Vehicle Capabilities

Vehicle Following

–Follow the preceding vehicle by fusing video and radar data to plan a safe path-following trajectory

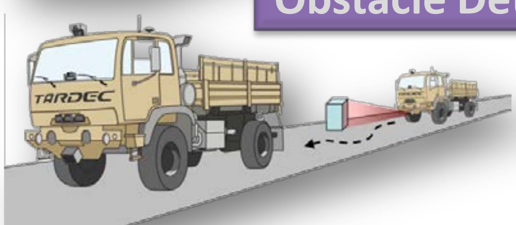


Road Following

–Maintain safe trajectories on both primary and secondary roadways by sensing road geometry

Interval Maintenance

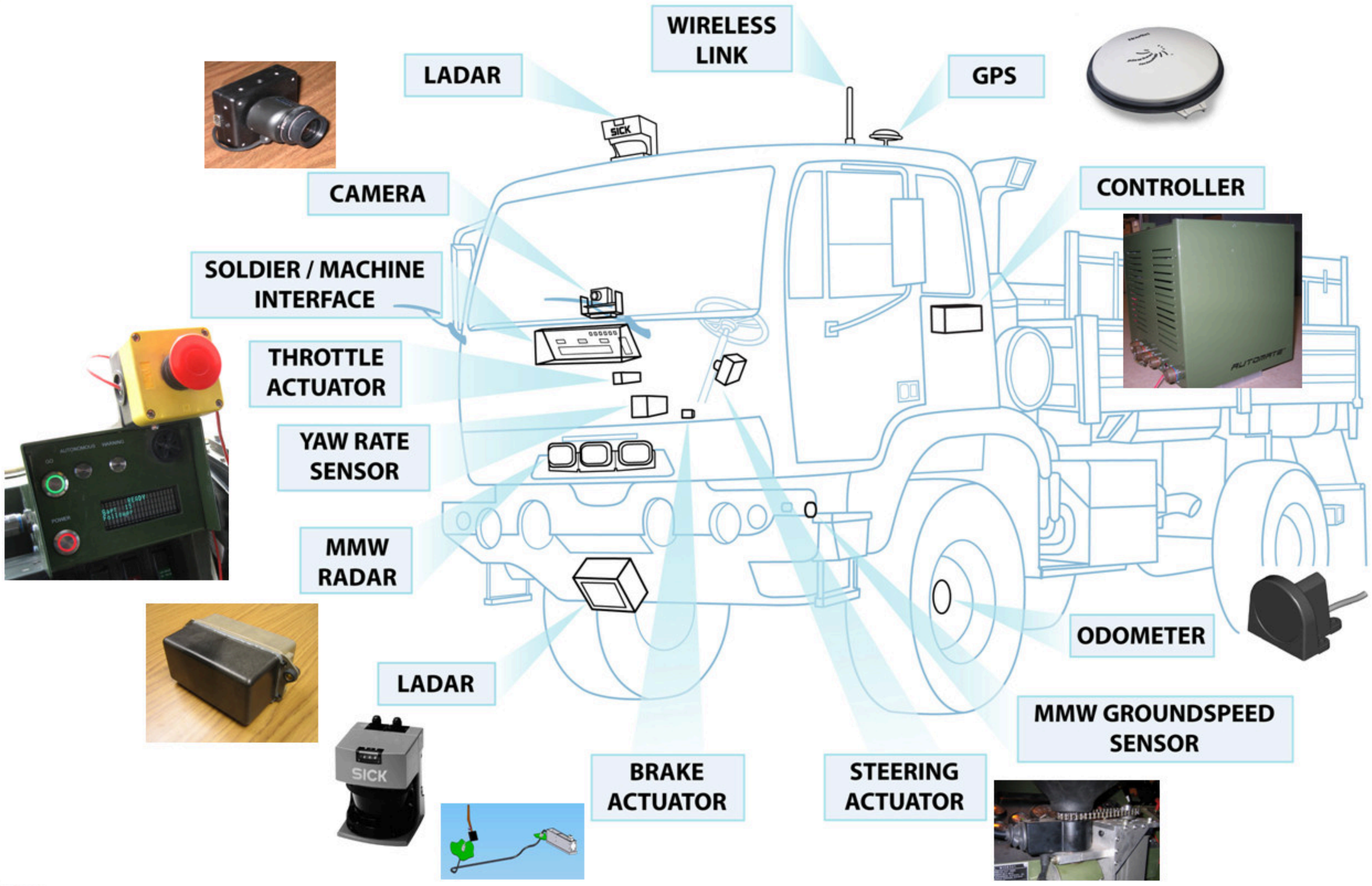
–Maintain a safe following distance behind the preceding vehicle and eliminate rear-end collisions



Obstacle Detection & Avoidance

–Sense and avoid static and dynamic obstacles that are near or move to intercept a planned trajectory

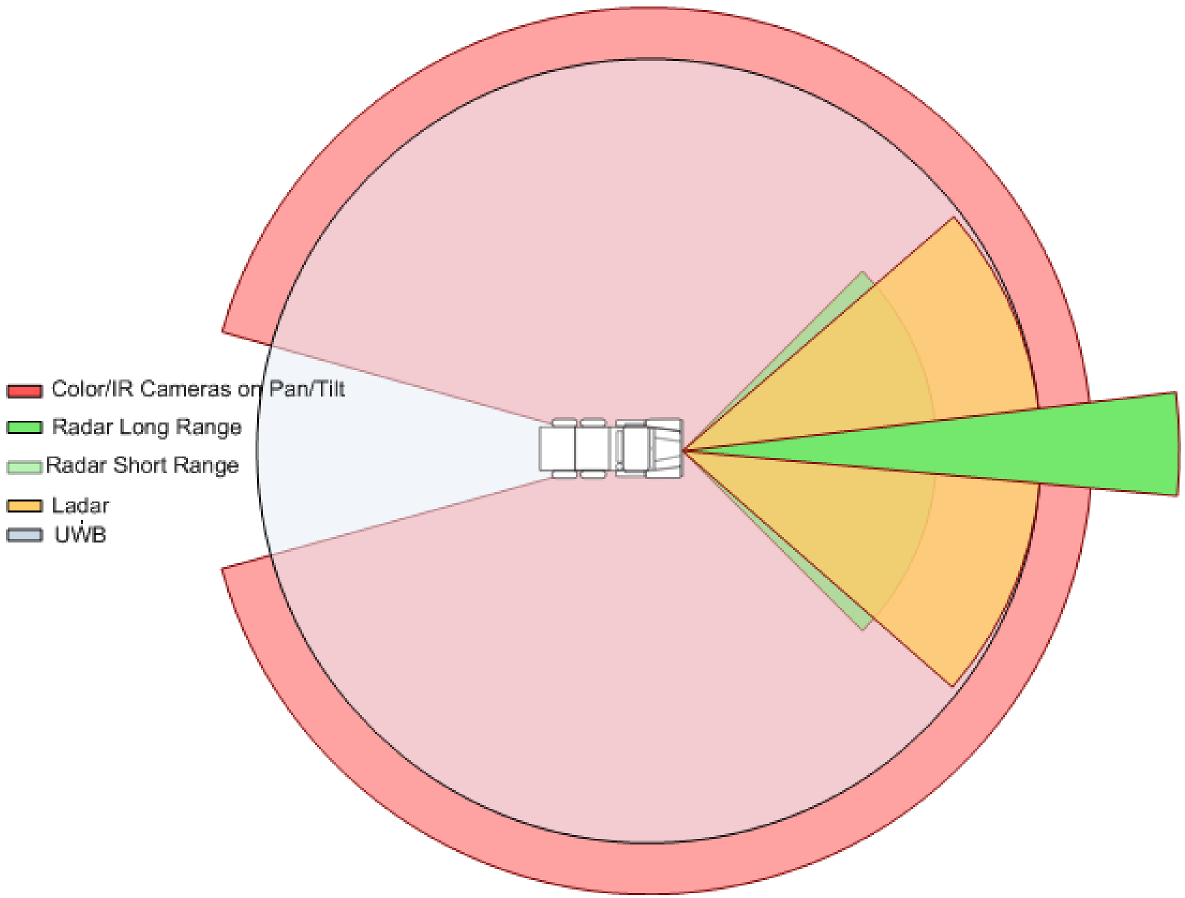
System Description



Low Cost Sensor Fusion

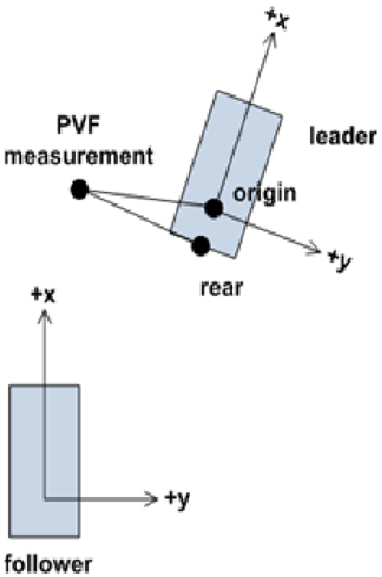
ROBOTIC SYSTEMS

- Sensor price point < $1,000
- Select sensors that cover maximum FOV
- Sensor's failure mechanisms overlapped by operation envelope of other sensors



Vehicle Detection

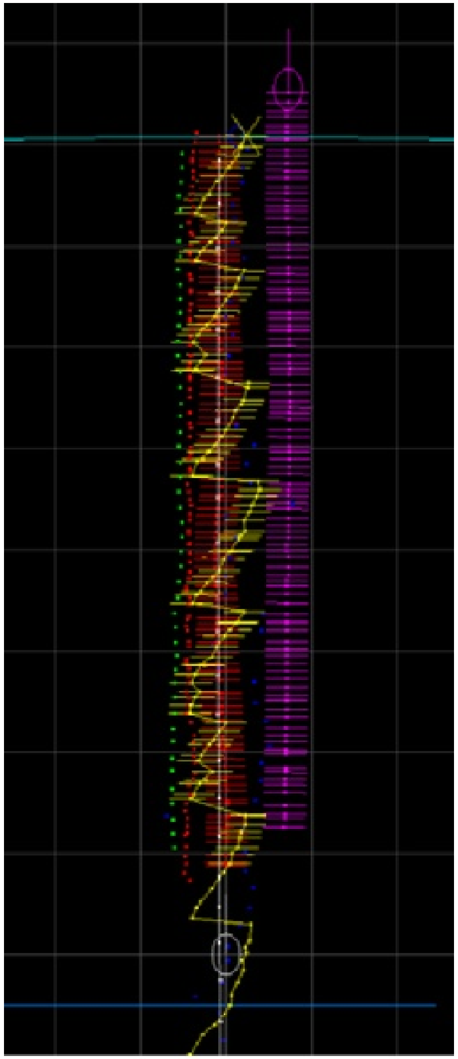
- Real Time Kinematic Ground Truth of sensor measurements shows sensor performance
- No single sensor has full or even adequate detection of vehicle



Sensor	Reliable Measurements	Reliable %	Unreliable Measurements	Unreliable %	Error Avg	Error Dev	Error Max
Camera	2766	16.10%	14416	83.90%	0.9	0.33	2.63
RADAR	7018	97.69%	166	2.31%	0.89	0.42	5.65
GPS	12880	74.49%	4412	25.51%	0.23	0.26	1.96
LVD	8476	93.38%	139	1.61%	0.96	0.32	2.41

Vehicle Tracking

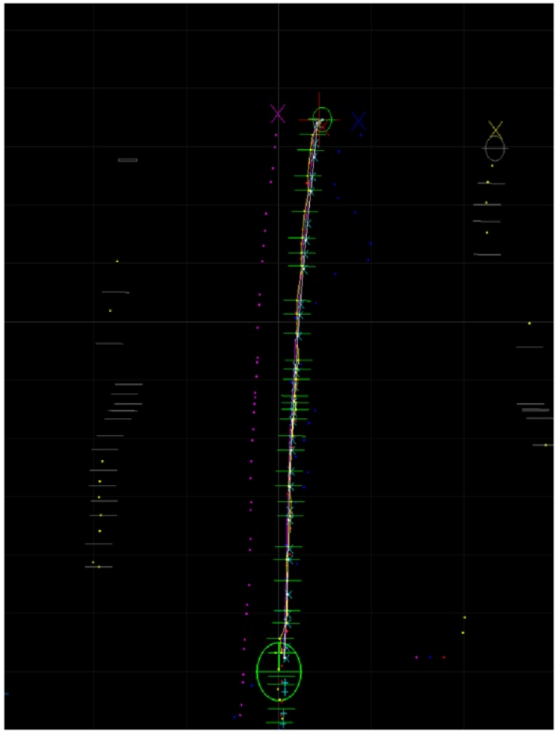
- Use Multiple Kalmans, One for Each New Sensor Measurement
- These Kalman Filters Represent Multiple Hypotheses Of The Lead Vehicle's Position, Speed, Heading, And Steering Radius.
- On Subsequent Input Cycles, Update Hypotheses
- Select Track Based on History, Lead Vehicle State, Number of Recent Supporting Measurements



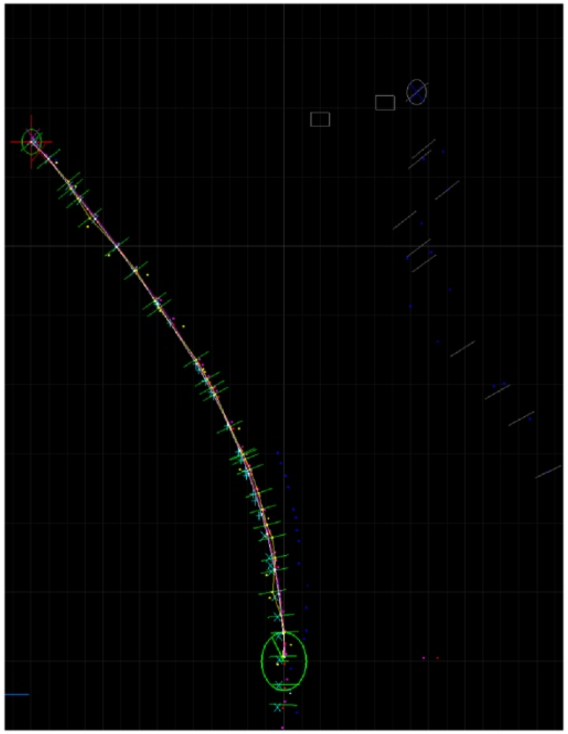
Trajectory Generation

- The last step is to output a trajectory representing all past estimates of leader position.
- If the Trajectory Can Be Approximated as a Good Estimate of Leader Tran Relative Trajectory, Best Path is a Transform into Follower's Tran Relative Frame
- Otherwise, PVF Generates a Trajectory by Smoothing and Filtering the Path of Previous Leader Position Estimates i.e., "Best" Kalman States Generated from Sensor Measurements.

PVF General Results



Ignoring false positives from camera



Ignoring false positives from radar

Conclusion

- The Use of Low Cost Sensors Can Provide an Effective Solution
  - Using Multiple, Over Lapping Sensors with Exclusionary Failure Mechanisms
  - Knowledge of Sensor Performance and Associated Covariance
  - Specifically Tuned to Solve Specific Problem
- CAST Provides a Feasible Solution to Relieve the Soldier of Driving in Order to Focus on Other Tasks